The "Quiet" Helicopter (S)

[redacted]

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[redacted] served in CIA's former Technical Services Division.

[redacted]

Editor's Note: In 1970, CIA's Technical Services Division (TSD) of the then Directorate of Plans undertook a program to construct a "quiet" helicopter which would be able to undertake dead-dark operations at low altitudes. The program's goal was to develop a vehicle that could clandestinely insert equipment or personnel into denied areas. (U//FOUO)

The details about the operation that the helicopter would support and the results of that operation cannot yet be revealed. But the speed with which the Agency met the project's technical demands is an outstanding example of managerial excellence. The ability to enlist the backing and participation of a number of technical personnel in the government, the military, and private industry and to mold them into an effective team was at the heart of this successful project, one whose long-term benefits have been substantial. And it was achieved at a remarkably low cost. (U//FOUO)

During the course of the program, a minimum of documentation was assembled. This article is aimed in part at providing some background on the program. (U//FOUO)

I returned to TSD in January 1970, after attending the Armed Forces Staff College, and was assigned to head up the Engineering Branch. [redacted] After examining many other options, it became apparent that it would take something like a helicopter to accomplish this mission. It was generally believed that any helicopter would have both an acoustic and radar signature that would be unacceptable and that range considerations would also be unacceptable. Despite these negatives, we decided to at least look at all the options for this approach. (C)

After examining several potential helicopters for this mission, the range and capability of the Hughes OH-6 suggested that it could be successfully modified. In 1964, this chopper had established a world record for unrefueled range by flying directly from Culver City, California, to Daytona Beach, Florida. The Advanced Research Projects Agency (ARPA) had done a low-effort study of three helicopters to see if their "noise" signature could be reduced. Again, the OH-6 had shown the most promise in this area. ARPA was then headed by Dr. Steven Lukasik [redacted] My boss, Dr. Sidney Gottlieb, C/TSD, backed us on pure guts, and he tracked our progress closely. This survey took less than a month. (C)

Assembling the Team

Within TSD, this effort was almost entirely put together by members of the Engineering Branch, with deputy chief [redacted] and [redacted] providing the most direct participation. [redacted] from the operations side of TSD, became the principal test pilot and hands-on operator. At that time, he was in a reserve Navy helicopter unit, and he had more than 1,000 hours in helicopter operations. He was key to a lot of our accomplishments. (C)

Technical Services Division

On the industry side, A. L. "Al" Browning of the Hughes Aircraft Corporation in Fullerton, California, was the principal leader and coordinator of this effort. At Hughes, Carl Schalbe was, in fact, the actual program manager, and he spent countless hours coordinating every aspect of the project. The Hughes "Aircraft" group does not build planes of any kind, but it is a world leader in electronics and air defense systems. The Hughes Tool Company in Culver City was the actual builder of the OH-6. Rod Taylor, a brilliant helicopter engineer, led a team of about 30 engineers and craftsmen that began constructing these helicopters. (C)

It was truly a "Skunk Works" type of operation that was located in an outbuilding at the Tool Company's Culver City factory. This building housed the original H-1 racer with which Howard Hughes had set several world records in the 1930s. In addition, it housed all the engines from the "Spruce Goose" were stored there, and every two weeks hot oil was run through the engines to keep them operable. (C)

There were several other key players in the Agency who supported this program, especially Charles Briggs, who was then the Comptroller. He guided this program through the bureaucracy with great skill and kept the naysayers off our backs. (C)

Our TSD contracting officer [redacted] worked miracles with both the contractual and payment aspects with the various industrial participants (not the least of which was getting the Hughes people to accept the fact that the Agency contracting officer would [redacted]. There were legitimate questions about this all the way up to DCI Richard Helms on how we were going to make it all work, but the DCI approved it, based on our research and the urgency of the requirement. There was a lot of faith involved with these key decisions. (C)

Through Dr. Lukasik, we made presentations to the principal Army staff about our program, including the vice chief of staff, General Palmer, and the chief of Army Aviation, Lieutenant General Williams. The vice chief supported the entire concept, but he pointed out that if the Army became directly involved, the whole program would be slowed down by the military bureaucracy. General Williams agreed to "loan" US Army pilots and OH-6s to support the program. In return, they would get considerable data on learning to fly helicopters off of 2D (TV) displays. That was one of the major unknowns when we went into this effort. (C)

Solving Technical Problems

From the first day, there were several seemingly unsolvable problems involving the "bird." For example, to reduce main rotor noise, the RPMs would have to be reduced. To regain the loss of lift that this would produce, we decided to create a five-blade rotor to replace the normal four-blade unit. (Both modifications turned up later in the civilian version of the helicopter known as the 500D model.) (C)

The second major "noise" attack had to do with the main gear box, which was a product of Western Gear, Inc. They modified some gear boxes for us that included "silicone" inserts in the main ring gear as a way of reducing the gear contact noise and improving the ability of the box to handle higher horsepower. The tail rotor and the tail rotor gear box were similarly modified. (C)

The engine (the Allison C-18) had its own story. It had a horsepower rating of 317, but it was derated in the case of the OH-6 to 250hp. It was a product of the Allison Division of General Motors in Indianapolis. We visited them for the specific purpose of finding ways to "push" this engine and to locate the ones with the lowest specific fuel consumption per hour. Talk about bureaucracy! The GM people were afraid that we would change even one "hair" on this without years of testing, and they

cited "liability" after "liability" reasons. Finally, they made Paul Baynes available to us. He was one of their roaming troubleshooters, and he took on our problems with a vengeance. (C)

In less than a week, Paul had indicated that horsepower possibilities in the order of 400hp from "stock" engines were possible and would give us the lowest specific fuel consumption per hour. He suggested that we deal with a facility in Burbank that was rebuilding these engines for both civil and military use, and that we select individual engines that had demonstrated the highest horsepower index when they were tested. This led to a quick program in which, as these rebuilt engines were tested, those that showed the highest output were first put aside and then replaced as even more powerful ones came along. In the end, we wound up with about six engines that had been selected from several hundred, and they were truly blue-ribbon specials. Even the Hughes people were astounded at the quality of these particular engines. (C)

Once the main quieting had been accomplished with the changes in the rotor systems and gearboxes, other interesting "signatures" started to emerge—things that would never be noted on a standard chopper. There was a noisy relief valve on the engine fuel system that Bendix cured for us, although they are probably still wondering why a slight noise like that would pose any problem. There were also a couple of rotating inverters that emerged as noisy, and these were replaced with solid-state devices that were lighter, better—and quiet. (C)

The final attack on the noise signature was the development of an exhaust muffler. We initially contracted with a famous acoustic engineering company in Boston which, after about three weeks, came up with nothing usable. We then found an engineer at Lockheed who was working on quieting problems of the Rolls Royce RB-211 engines. We tried to obtain his services, but Lockheed said he could not be spared from their programs. He wound up doing this in his garage at night, and, within a week, had produced a design that was almost perfect. This was one more case where a specific individual with specific skills came through and saved the day. (C)

The helicopter would require an auxiliary fuel-tank system which led us onto several paths. We finally had tanks constructed that were "semipliable" and were filled with foam. These were tanks that had been developed for the racing world, and they had great crash resistance and a light weight when empty. A fast-acting "dump" system was installed which would enable the pilot to offload this fuel immediately in the event of an emergency. When fully loaded, the OH-6 was considerably beyond the weight limit that would allow a safe "auto rotation," but this dump system enabled the pilot to restore the aircraft to a safe flight profile immediately. (C)

This aircraft had an empty weight of around 1,100 pounds, and we were operating with takeoff weights in the order of 3,000 pounds or more. Hughes considered a safe maximum to be about 2,400 pounds, a weight that would make feasible an emergency landing under all circumstances. Our testing of this system proved it worked exceptionally well. (C)

The "noise" signature on this vehicle was a direct product of speed. The quietest mode was about 85 knots, although it still had a low detectability up to about 120 knots. In fact, the mission could be tailored so that the minimum noise level would only be required at certain locations on the flight profile. The maximum-range speed (lowest fuel per mile) was in the order of 110 knots. This "quiet" envelope became broader as the mission progressed and the total weight came down with fuel burnoff. (U//FOUO)

Professional flight planning became the watchword. Missions would have to be carefully planned around both the quieting aspect and specific speeds and altitudes in order to avoid hostile radar detection. Fortunately, these profiles were compatible and not mutually exclusive. (U//FOUO)

The extra horsepower of this unit required major changes in the construction of the helicopter itself. The tail-boom system had to be reinforced and altered, and the new five-blade rotor produced tail-rotor interface problems that were eventually solved. The true key here,

however, was the speed with which these problems were addressed and corrected. The first test bird was up and flying in about 60 days, and it was fully operational in about six months. (U//FOUO)

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The Navigation Systems

At the same time that the development of the chopper was under way, the entire problem of navigating this unit at low-levels (100 feet or less above ground level) in a dead-dark environment was being vigorously pursued. We had concluded at the outset that the only thing that would make cross-country flight over varied terrain under dead-dark conditions work was a high-performance Forward-Looking Infra-Red (FLIR) system. This was probably one of the major innovations that emerged from this program, and it has had a long-term effect on many of our subsequent military aviation systems. (U//FOUO)

A FLIR is a TV system that looks at temperature differences rather than visible light—the world as seen through the eyes of a thermometer. Unfortunately, we had also concluded that the maximum weight we could stand for this system was about 85 pounds, and the experimental units then flying were about 300 pounds. To make matters worse, they were terrible performers, with low thermal sensitivity. Using these units was a lot like looking through a venetian blind with some of the slats skewed. We investigated several units that were under development at Hughes, Aerojet General, and Raytheon, but they all came up too heavy, too insensitive, and had poor thermal resolution. (C)

We approached the systems people at Hughes with this problem and told them we were willing to look at anything that might be around, even if it were still in the idea stage. There were two young engineers who had a spectacular idea that was totally unproven but which would result in a system weighing in at less than 15 pounds. Despite the misgivings of the Hughes management about taking such a risk on an unproven idea, we opted to turn the two loose to see what they could do. We had no real choice. Unless we could get the weight and performance that this idea envisioned, the program would fail. (C)

Until this time, all the thermal-imaging equipment consisted of long linear arrays that were mechanically scanned and had wide variations in sensitivity line to line. The idea was to take a single array of about 15 detectors and electronically "stack" them into a single point by the use of delay lines between each element. It could then be treated as a "single-point" detector with the power and sensitivity of 15 units and could scan mechanically in both the horizontal and vertical planes. Near-standard TV rates could be achieved. To increase sensitivity even more, we elected to use a detector operating at liquid helium temperatures rather than liquid nitrogen. In fact, the best sensor then available was actually being made by Raytheon (but not used in this time-delay mode), and they made this available to us for this program. (C)

In less than 60 days, the two engineers had a fully operational FLIR system on the bench and operating. It performed so well that it was truly a ten-year jump in the technology and instantly rendered just about every other idea or system of this type obsolete. From both a display and sensitivity standpoint, it was even possible to recognize facial features just by the temperature differences in the blood-vessel patterns inherent in any person. (Pilots inside the helicopters in which these FLIRs were eventually installed could recognize individual ground-crew members as they walked in front of the aircraft.) (U//FOUO)

Although the FLIR was to become the primary navigation aid, we also installed an Inertial Navigation System (INS) made by Singer-Kearfoot. At that time, the best unit available had an error rate of about 1 nautical mph, but Singer put some packages together for us that used "selected" gyros that yielded us an error rate of less than one-fourth nautical mph. This was to be an "option" package, but, after testing, the pilots all wanted it retained because it enabled them to take up an exact heading when they left each checkpoint. Normally, with other navigation systems, the pilot has to fly a course for some time

and then "split the needle" to compensate for crosswinds. With the INS system, they could immediately take up a heading that was on the money. (C)

The Testing Program

One of the great unknowns was whether or not pilots could safely adapt to flying this unit from a TV-type, that is, two-dimensional display. Even before the first chopper was flying, we took one borrowed OH-6 and installed a standard TV unit with the cockpit on one side completely closed off. With this as a training vehicle, Cal Lacey, the Hughes test pilot, and the two Army pilots on loan started an intensive investigation of this in normal flying situations. The bottom line was that it turned out to be possible, but the "adjustment" time was just about equivalent to learning to fly for the first time. It took about 8 hours before a pilot gained any confidence, and about another 30 hours to become proficient. By 50 hours total time, they were doing amazing things flying with this 2D display. (C)

As a practical matter, while flying initially on the TV and later on the FLIR, the pilots experienced no significant problems in learning to hold heading or to follow a prescribed track over the ground (given the assistance of a radar altimeter). Similarly, no great problems were experienced in learning to hold heading and altitude in a hover (once a hover had been established), to go down from a low hover to a landing, or to take off and climb out. But learning to

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transition from forward flight to a stationary hover over a preselected point was a problem of unexpected magnitude. This problem was experienced by all pilots, and the reaction of each new pilot on his first attempt was easily predicted and invariably observed. (U//FOUO)

When a helo transitions from forward flight to a hover, it has to decrease and eventually cease its forward movement over the ground. This is accomplished by putting the helo into a nose-up attitude. Then, as the hover altitude and position are reached, and as ground speed decreases to zero, the helo is put back into a level attitude. This means that just as the helo reaches a hover, the pilot pushes the nose down, and this meant, in our case, that the nose-mounted FLIR was pushed closer to the ground. Hence, although the helo itself was merely changing its attitude (not its altitude) to the pilot, who was watching things through the FLIR, everything in the FLIR picture of his ground reference suddenly began to get closer and bigger. It appeared that the helo had suddenly started forward and down at an alarming rate of descent. The immediate pilot reaction was to climb and back up. This exaggerated backward climb generated a lot of humor at the expense of each pilot on his first attempted landing on the FLIR. (U//FOUO)

Following several weeks of flight testing, which proved the operational feasibility of the overall system and refined pilot and mission procedures. [redacted]

There was an interesting side development in this period. DCI Helms was still concerned about what we meant by quiet, and he did not trust the evaluations of the engineers. As a result, CIA General Counsel Larry Houston asked us to arrange a night demonstration flight for him a [redacted] We had a standard OH-6 make a low-level flyby, and then, about three minutes later, we had the quiet bird fly

over with no lights. Houston, who was chatting with project officers, did not even notice it. We then had it fly over a second time and had the pilot turn on its running lights when he was directly overhead. Houston was impressed and passed this on to the Director. The question of acoustic detectability was no longer an issue. (C)

The Radar Air Defense Problem

From the beginning, there was great concern about the ability of hostile air defense systems to detect this vehicle, and we spent considerable time working on this problem. Hughes Aircraft (Fullerton) was the primary builder of most air defense systems, and it had some remarkable analytic abilities in this area. It turned out that the main rotor on this aircraft was made of composite materials and had a very low radar "signature." In addition, it was envisioned that it would be flying mostly nap-of-the-earth missions, which would provide considerable direct protection from air defense systems. (C)

Hughes had a computer program called the Radar Coverage and Penetration Analysis System (RACPAS), which was primarily used for the purpose of siting radars and air defense systems worldwide. It was designed to show optimum placement of systems to ensure the greatest possible coverage. We turned this program around and plotted the hostile radars. From this, it was possible to work out flight paths that had a low probability of detection. (C)

There was one other characteristic of the helicopter that further lowered its detection probability, and that had to do with the technical operation of Moving Target Indicator (MTI) systems inherent in virtually all radars. These are designed to enhance detection of low-flying targets that are theoretically "buried" in the ground clutter. These systems are usually built with "blind" speeds of between 50 to 75 knots and will not detect targets with "radial" speeds below this. As a result, even in those areas where air defense systems would normally detect the helicopter, it was possible to slow down below these critical speeds and go undetected. Our testing of this entire concept produced some exceptionally good results. (C)

Long-Term Benefits

This system had to be considered a total technical success, and it was employed operationally. Moreover, there were several aspects of this program that have had, and continue to have, long-range positive effects:

- The development of this special FLIR spawned a whole new generation of devices that dramatically changed night military operations. Much of what happened in the Gulf War in this area can be traced back to this development.

- We proved that helicopter operations can be worked from 2D displays and that, with proper training, this can be done safely. Later, these systems would be backed up for precise landing with night-vision goggles on one pilot, with the FLIR providing primary guidance.

- Helicopters can be quieted to a remarkable degree, and missions can be configured to ensure a low detectability by air defense radar systems. (U//FOUO)

We proved anew that American companies can be highly cooperative when they are presented with problems that have national significance and when they are not burdened with excessive red tape. The number of companies that freely supplied us with either expert help or equipment would fill a page. Both the official and unofficial help we received from the US Army was outstanding. At one point, they supplied us with their transmission and component engineers from St. Louis to evaluate the maximum number of hours we could "push" some of these components with a high degree of reliability. General Williams gave us everything we asked for, and then some. (U//FOUO)

Maintenance considerations, particularly pre-mission checking of everything, took on a high priority. Hughes made a two-man team available for direct support and these people were so professional and competent that there were virtually no system failures of any kind while in flight. Based on the fact that many components were being "pushed" beyond normal limits, we set a low useful life on many components, particularly the transmissions. Typically, these were rerated at about 50 hours. Safety

and mission reliability were paramount, and the Hughes team never let us down. (C)

The last remaining bird was turned over to the Army Night Vision Labs at Fort Belvoir, where it continued for many years to function as a test platform. I was told later that they finally contacted Hughes for a replacement tail-rotor gearbox when they had passed over 2,500 hours—far more than the 50 hours we had contemplated. I was also told several years later that they still did not have anything in inventory that could approach the performance level that we had achieved. If nothing else, we gave them a target to shoot at. (C)

A final word of tribute. One night about 8 p.m., I stopped in the Skunk Works at Culver City, where I found 15 people hard at work. I commented to [redacted] that I was going to get some horrendous overtime bills from this, and he informed me that each one of the people who were there were working on this voluntarily. It turned out that they considered 16-hour days as normal. I wish we could have given each one of those people a medal. (C)